(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 469 023 B2

(12) **NEW EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the opposition decision:
01.12.1999 Bulletin 1999/48

(45) Mention of the grant of the patent:
18.10.1995 Bulletin 1995/42

(21) Application number: **90906299.4**

(22) Date of filing: **19.04.1990**

(51) Int Cl.[6]: **G10K 15/02**

(86) International application number:
PCT/GB90/00597

(87) International publication number:
WO 90/13109 (01.11.1990 Gazette 1990/25)

(54) SOUND SYNTHESIZER IN A VEHICLE

GERÄUSCHSYNTHETISIERER IN EINEM FAHRZEUG

SYNTHETISEUR DE SON POUR VEHICULE

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB IT LI LU NL SE

(30) Priority: **20.04.1989 GB 8908980**

(43) Date of publication of application:
05.02.1992 Bulletin 1992/06

(73) Proprietor: **GROUP LOTUS LIMITED**
Norwich Norfolk NR14 8EZ (GB)

(72) Inventors:
- **McDONALD, Anthony, Malcolm "Highfields" Norfolk (GB)**
- **QUINN, David, Charles "Nirvana" Norfolk (GB)**
- **PERRY, David, Christopher "Sommerset" Attleborough Norfolk (GB)**

(74) Representative: **Mayes, Stuart David et al**
BOULT WADE TENNANT,
27 Furnival Street
London EC4A 1PQ (GB)

(56) References cited:

WO-A-88/02912	WO-A-90/13104
DE-A- 2 734 948	DE-A- 3 420 463
GB-A- 2 018 144	US-A- 4 219 962
US-A- 4 274 225	US-A- 4 289 307

- **R.Koch: "Einfluss des Fahrzeuginnengeräusches auf da subjektive Beschleunigungsempfinden untersucht an einem Realfahrzeug", diploma thesis submitted in September 1986 at Lehrstuhl für Ergonomie, Technical University Munich;**
- **W. Huber: "Entwicklung eines Simulators zur Erzeugung von wirklichkeitsnahen Kraftfahrzeuggeräuschen in Abhängigkeit von Motordrehzahl und Geschwindigkeit", diploma thesis submitted in January 1976 at Lehrstuhl für Ergonomie, Technical University Munich;**

EP 0 469 023 B2

Description

[0001] The invention relates to the treatment of noise in vehicles, in particular road vehicles.

[0002] The driver and passengers in the cabins of conventional passenger cars are exposed to a great deal of externally generated noise, due primarily to the vehicle engine. Various proposals hae been made for reduction of such ambient noise but the present invention is concerned with the enhancement of the vehicle noise experienced by the cabin occupants during normal driving conditions.

[0003] DE-A-3420463 discloses a sound enhancement system for a vehicle in which an engine speed proportional frequency signal is taken from an ignition coil and fed to a frequency changer which changes the frequency and generates an output which is selectable by a switch to drive a loudspeaker via an adjustable amplifier. The vehicle sound simulated depends on the frequency selected. This system is however limited in that only a single frequency can be generated at a time and complex sound cannot be generated in response to a range of vehicle operating conditions.

[0004] The present invention provides a sound enhancement system for use in a vehicle, the system comprising source means adapted to provide first signals related to operation of the vehicle and the engine thereof, and generating means responsive to the operation of the vehicle and the engine thereof to provide output signals for transducer means to generate simulated vehicle operating sound; characterised in that said first signals comprise a signal or signals responsive to vehicle acceleration provided by a transducer which relate to one or both of throttle position signal or gear changes and the first signals comprise a signal or signals provided by one or both of a microphone responsive to engine noise and a vibration sensor responsive to engine-generated vibrations; in that the system includes a source of stored signals representing vehicle operating sound to be simulated related to vehicle operation; and in that said generating means is responsive to said first signals to employ said stored signals to provide said output signals.

[0005] The source of stored signals representing vehicle operating sound can be a prerecorded source. The generating means can comprise a synthesizer and said source of stored signals can comprise a micro-processor for controlling said synthesizer, said micro-processor being adapted to employ said stored signals to control said synthesizer in response to said first signals to trigger the generation of said output signals at appropriate times.

[0006] The microphone can be located in the vehicle cabin to provide feedback to the microprocessor. The microprocessor controlling the synthesizer can store signals representing a desired sound to which the synthesizer can be arranged to adapt the transducer output.

[0007] The sounds heard by the user of a system embodying the invention can represent for example the sounds of a racing car or other high-performance road vehicle. The system can then be such that these sounds are heard by the cabin occupants whilst the vehicle is being driven, so as to enhance the occupants driving experience.

[0008] In particular, the sounds of a high powered engine undergoing sharp acceleration can be produced in response to acceleration of a vehicle fitted with the system of the invention in ordinary driving conditions. The system is responsive to gear changes and/or throttle movement.

[0009] One or more loudspeakers and/or one or more vibration actuators of the system are typically located in the vehicle cabin but instead or as well one or more loudspeakers or actuators can be positioned in the engine compartment, or on appropriate engine or body parts to effect or to modify vibration thereof, so that the sound from them is heard by the vehicle cabin occupants, and by persons outside the vehicle by the same route as sound from the vehicle engine.

[0010] Although the system of the invention can stand alone, it is conveniently integrated wit the in-car-entertainment (I.C.E) systems now typically provided in passenger cars. The vehicle operation related sound can be integrated with entertainment sound and can be produced in alternation with it, either selectively or according to vehicle operation; for example the former may be heard during acceleration only, giving way to entertainment sound once cruising speed has been reached. The system of the invention can also be integrated with an active noise reduction system which can reduce ambient noise by generating within the vehicle cabin sound vibrations of phase and amplitude such as to cancel or reduce unwanted noise.

[0011] Noise reduction can thus be operative to prevent interference with the desired sound related to vehicle operation, as well as with entertainment sound, or it may be operative only as long as entertainment sound is being produced or when an integrated system is otherwise out of use.

[0012] The invention is further described below, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a block circuit diagram of a combined audio entertainment and noise control or processing system embodying the invention.

[0013] The system illustrated in Figure 1 is an integrated system comprising all the components necessary to provide in the cabin of a passenger motor car enhanced vehicle operation noise. Audio entertainment and/or ambient noise reduction can also be provided, as the operator of the system may desire.

[0014] The in-car entertainment (I.C.E) components of the system comprise an audio signal source constituted by at least one of a radio tuner 2 connected to an aerial 4, and a deck or decks 5 for playing one or more of compact discs, digitally recorded tapes or cassettes. The outputs from the tuner 2 and deck or decks 5 are

fed to a pre-amplifier 6 fitted with conventional control arrangements 7 for signal source selection and for output adjustment, such as volume and bass and treble controls, or graphic equalization, and switching instruments to be described. These I.C.E. components will typically provide signals on a plurality N of output channels and balance and fader controls will then be provided. The pre-amplifier outputs are supplied by way of a mixer 9, preferably a balanced mixer, to power amplifier means 10 which powers one or more loudspeakers 11 operative in the vehicle cabin.

[0015] For enhanced vehicle sound production, the system includes a prerecorded sound source 15 which can comprise a deck of one or other of the types of deck mentioned with reference to the deck 5 , but which need not have the usual facility for selective replacement of the signal storage medium. Operation of the source 15 is dependent on a control signal related to vehicle operation, the control signal relating to throttle movement and/or gear changes, derived from a transducer 16 and supplied to the source on line 17, so that the source delivers signals representing the sounds of acceleration of a high powered vehicle, or other such desirable sounds, during acceleration of the vehicle in which the system is installed.

[0016] The system includes one or more microphones 20 providing outputs representing actual vehicle engine noise and a signal treatment unit constituted as a synthesizer 24 controlled by a microprocessor 25. Instead of or as well as the microphone or microphones 20, the system can include one or more transducer 22, for example vibration sensors, responsive to engine operation. The input from the or each microphone 20 or transducer 22 is then used to trigger the generation of a desired output from the synthesizer 24. Enhanced engine or vehicle interior noise is provide, dependent on vehicle operation, as indicated by the control signal from the transducer 16.

[0017] The outputs of the source 15 and the synthesizer 24 are supplied to the pre-amplifier 6 on line 19 for sound production in the vehicle cabin by way of the amplifier means 10 and the loudspeakers 11. In addition or instead the pre-amplifier output derived from the source 15 or the synthesizer 24 can be used to drive one or more loudspeakers 26 located externally of the vehicle cabin, for example, in or near the engine compartment of the vehicle so as to enhance the sound actually produced by the vehicle engine and/or a vibration actuator 27 operatively related to a vehicle panel 28. The loudspeaker 26 and/or actuator 27 is powered by way of one or more power amplifiers 29.

[0018] For noise reduction, the system includes an adaptive noise cancellation controller 30 which may advantageously be of the kind described in WO 88/02912.

[0019] The controller 30 provides, on L channels, output signals derived from a reference signal by adaptive filtering carried out by a programmed microprocessor and memory unit in dependence on error signals from one or more microphones 31. The microphone 31 may be inconspicuously located in the cabin and the reference signal may be derived directly from the vehicle engine, as described in WO 88/02912.

[0020] The output of the one or more microphones 31, or of one or more similarly located microphones if no noise reduction facilities are provided can be fed back to the microprocessor 25, on line 32, so as to provide adaptive control of the unit, as towards a predetermined enhanced noise signal defined in a memory in the unit or in the microprocessor.

[0021] The outputs from the pre-amplifier 6 and the controller 30 are fed to the balanced mixer 9 operative to provide outputs for the power amplifier means 10 combining a desired audio signal fro one or other of te sources 2 and 5 together, with a noise cancelling signal from the controller 30, on which the amplifier control arrangements 7 have no effect.

[0022] The system is provided with an on/off switch controlling the power amplifiers 10 and 29 and the mixer 9, and selector switches for selecting any one or more of the enhanced noise facility, the entertainment facility, and the noise reduction facility.

[0023] The loudspeakers 11 will conveniently match in number the number of the output channels of the pre-amplifier 6, but there may be M channels between the balanced mixer 9 and the amplifiers 10, where M is equal to or greater than the larger of the N entertainment channels or the L noise reduction channels.

[0024] One or more of the sources 5 and 15 and the synthesizer 24 may incorporate a pre-amplifier and the output or outputs can then be supplied to the mixer 9 directly as indicated in the figure by broken lines.

Claims

1. A sound enhancement system for use in a vehicle, the system comprising source means (16, 17, 20, 22) adapted to provide first signals related to operation of the vehicle and the engine thereof, and generating means (15, 24) responsive to the operation of the vehicle and the engine thereof to provide output signals for transducer means (11, 26, 27) to generate simulated vehicle operating sound; characterised in that said first signals comprise a signal or signals responsive to vehicle acceleration provided by a transducer (16) which relate to one or both of throttle position or gear changes and the first signals comprise a signal or signals provided by one or both of a microphone (20) responsive to engine noise and a vibration sensor (22) responsive to engine-generated vibrations; in that the system includes a source (15, 25) of stored signals representing vehicle operating sound to be simulated related to vehicle operation; and in that said generating means (15, 24) is responsive to said first signals to employ said stored signals to provide said output

signals.

2. A sound enhancement system as claimed in Claim 1 characterised in that said generating means (15, 24, 25) comprises a prerecorded sound source (15).

3. A sound enhancement system as claimed in Claim 1 characterised in that said generating means (15, 24) comprises a synthesiser (24), and said source (15, 25) of stored signals comprises a microprocessor (25) for controlling said synthesiser (24), said microprocessor (25) being adapted to employ said stored signals to control said synthesiser (24) in response to said first signals to trigger the generation of said output signals at appropriate times.

4. A sound enhancement system as claimed in any preceding claim characterised in that said transducer means (11, 26, 27) comprises at least one of:

   a loudspeaker (26) located in or near the region of an engine of the vehicle,
   a loudspeaker (11) located in a cabin of the vehicle, and
   an actuator (27) operatively related to a body panel (28) of the vehicle for causing vibration of said body panel (28).

5. A sound enhancement system as claimed in any preceding claim characterised in that said vehicle includes an in-car entertainment system (4, 2, 5, 6, 7, 10, 11) providing an audio signal source (2, 5), the system including a mixer (9) arranged to mix said output signals and signals from said audio signal source (2, 5) to generate a mix of said simulated vehicle operating sound and sound from said audio signal source (2, 5).

6. A sound enhancement system as claimed in any preceding claim further characterised by a noise cancellation system (30, 31, 32) including at least one error sensing microphone (31), a noise cancellation controller (30), and means (32) to supply signals output from the or each said error sensing microphone (31) to said noise cancellation controller (30), said noise cancellation controller (30) being adapted to generate noise cancelling signals adaptively in response to the output from the or each said error sensing microphone (31) to reduce undesired noise, the system including a mixer (9) adapted to mix said output signals and said noise cancelling signals to generate said simulated vehicle operating sound.

7. A sound enhancement system as claimed in Claim 3 characterised by a memory, at least one error sensing microphone (31), and means (32) to supply signals output from the or each said error sensing microphone (31) to said microprocessor (25), said microprocessor (25) being operative to adapt said stored signals in response to signals from the or each said error sensing microphone (31) such that said simulated vehicle operating sound generated by said synthesiser (24) attains a predetermined vehicle operating sound defined in said memory or said microprocessor (25).

Patentansprüche

1. Geräuschverstärkungssystem zur Verwendung in einem Fahrzeug, mit Signalquellen (16,17,20,22) zur Bereitstellung von auf den Betrieb des Fahrzeugs und seines Motors bezogenen ersten Signalen, und Signalerzeugem (15,24), die auf den Betrieb des Fahrzeugs und seines Motors ansprechen und Ausgangssignale abgeben für Wandler (11,26,27), die simulierte Fahrzeugbetriebsgeräusche erzeugen, dadurch **gekennzeichnet,** daß die ersten Signale ein Signal oder Signale umfassen, die von einem Wandler (16) in Abhängigkeit von der Fahrzeugbeschleunigung geliefert werden und die sich auf die Drosselklappenstellung und/oder auf Gangwechsel beziehen, und daß die ersten Signale ein Signal oder Signale auffassen, die von einem Mikrophon (20) in Abhängigkeit vom Motorgeräusch und/oder einem Vibrationssensor (22) in Abhängigkeit von motorbedingten Vibrationen geliefert werden; daß das System eine Quelle (15,25) von gespeicherten Signalen umfaßt, die Fahrzeugbetriebsgeräusch darstellen, das entsprechend der Fahrzeugbetätigung simuliert werden soll; und daß die Erzeugermittel (20,24) auf die ersten Signale ansprechen, um die gespeicherten Signale zur Erzeugung der Ausgangssignale zu verwenden.

2. Geräuschverstärkungssystem nach Anspruch 1, dadurch **gekennzeichnet,** daß die Erzeugermittel (15,24,25) eine Quelle (15) mit Tonaufzeichung umfassen.

3. Geräuschverstärkungssystem nach Anspruch 1, dadurch **gekennzeichnet,** daß die Erzeugermittel (15,24) einen Synthesizer (24) umfassen und daß die Quelle (15,25) für gespeicherte Signale einen Mikroprozessor (25) zum Steuern des Synthesizers (24) aufweist, wobei der Mikroprozessor (25) die gespeicherten Signale zur Steuerung des Synthesizers (24) in Abhängigkeit von den ersten Signalen verwendet, um die Erzeugung der Ausgangssignale zu geeigneten Zeitpunkten auszulösen.

4. Geräuschverstärkungssystem nach einem der vorangehenden Ansprüche, dadurch **gekennzeichnet,** daß die Wandler (11,26,27) umfassen:

einen Lautsprecher (26), der in oder nahe dem Motorbereich des Fahrzeugs angeordnet ist, einen Lautsprecher (11), der im Fahrgastraum des Fahrzeugs angeordnet ist, und/oder mindestens einen mit einem Fahrgestellblech (28) des Fahrzeugs betriebsmäßig verbundenen Aktuator (27) zum Erzeugen einer Vibration des Fahrgestellblechs (28).

5. Geräuschverstärkungssystem nach einem der vorangehenden Ansprüche, dadurch **gekennzeichnet,** daß das Fahrzeug eine Musikanlage (4,2,5,6,7,10,11) enthält, die eine Audiosignalquelle (2,5) liefert, wobei das System einen Mixer (9) umfaßt, der die Ausgangssignale und die Signale von der Audiosignalquelle (2,5) mischt, um eine Mischung des simulierten Fahrzeugbetriegsgeräusches und des Tons von der Audiosignalquelle (2,5) zu erzeugen.

6. Geräuschverstärkungssystem nach einem der vorangehenden Ansprüche, ferner gekennzeichnet durch ein Geräuschunterdrückungssystem (30,31,32) mit mindestens einem Fehlererfassungsmikrophon (31), einem Geräuschunterdrückungskontroller (30) und Mitteln (32) zur Zuführung von Ausgangssignalen von dem oder jedem fehlererfassenden Mikrophon (31) zu dem, wobei der Geräuschunterdrückungskontroller (30) Geräuschunterdrückungssignale adaptiv in Abhängigkeit vom Ausgangssignal von dem oder jedem Fehlererfassungsmikrophon erzeugt zur Unterdrückung von unerwünschten Geräuschen, wobei das System einen Mixer (9) umfaßt, der die Ausgangssignale und die Geräuschunterdrückungssignale mischt, um das simulierte Fahrzeugbetriebsgeräusch zu erzeugen.

7. Geräuschverstärkungssystem nach Anspruch 3, gekennzeichnet durch einen Datenspeicher, mindestens ein Fehlererfassungsmikrophon (31) und Mittel (32) zur Zuführung von Ausgangssignalen von dem oder jedem Fehlererfassungsmikrophon (31) zu dem Mikroprozessor (25), wobei der Mikroprozessor (25) im Betrieb die gespeicherten Signale in Abhängigkeit von den Signalen von dem oder jedem Fehlererfassungsmikrophon (31) anpaßt derart, daß das von dem Synthesizer (24) erzeugte simulierte Fahrzeugbetriebsgeräusch sich auf ein in dem Datenspeicher oder dem Mikroprozessor (25) vorgegebenes Fahrzeugbetriegsgeräusch einstellt.

Revendications

1. Système d'amélioration du son destiné à l'utilisation dans un véhicule, le système comprenant des moyens de source (16, 17, 20, 22) aptes à fournir des premiers signaux en liaison avec la marche du véhicule, et des moyens de génération (15, 24) sensibles à la marche du véhicule pour fournir des signaux de sortie destinés à des moyens de transducteur (11, 26, 27) pour générer un son de marche simulée du véhicule ; caractérisé en ce que les premiers signaux comprennent deux ou plus de deux signaux à partir d'un groupe comprenant un signal d'accélération de véhicule, un signal de marche du moteur, un signal de position de soupape des gaz et un signal de changement de vitesse ; en ce que le système comprend une source (15, 25) de signaux mémorisés représentant le bruit de marche du véhicule à simuler en liaison avec la marche du véhicule ; et en ce que les moyens de génération (15, 24) sont sensibles aux premiers signaux pour employer les signaux mémorisés et fournir les signaux de sortie.

2. Système d'amélioration du son selon la revendication 1, caractérisé en ce que les moyens de génération (15, 24, 25) comprennent une source de son préenregistrée (15).

3. Système d'amélioration du son selon la revendication 1, caractérisé en ce que les moyens de génération (15, 24) comprennent un synthétiseur (24), et la source (15, 25) des signaux mémorisés comprenant un microprocesseur (25) pour commander le synthétiseur (24), le microprocesseur (25) étant apte à utiliser les signaux mémorisés pour commander le synthétiseur (24) en réponse aux premiers signaux pour déclencher la production des signaux de sortie au moment voulu.

4. Système d'amélioration du son selon l'une quelconque des revendications précédentes, comprenant les moyens de transducteur (11, 26, 27) caractérisé en ce que les moyens de transducteur (11, 26, 27) comprennent au moins l'un de :

   au moins un haut-parleur (26) situé dans ou à proximité de la zone du moteur du véhicule ;
   au moins un haut-parleur (11) situé dans une cabine du véhicule ; et
   au moins un organe d'actionnement (27) relié de façon opérante à un flanc de la carrosserie (28) du véhicule pour provoquer la vibration du flanc de carrosserie (28).

5. Système d'amélioration du son selon l'une quelconque des revendications précédentes, caractérisé en ce que le véhicule comprend un système de divertissement interne (4, 2, 5, 6, 7, 10, 11) fournissant une source de signaux audio (2, 5), le système comprenant un mixeur (9) apte à mixer les signaux de sortie et les signaux provenant de la source de

signaux audio (2, 5) pour produire un mélange du son fonctionnel simulé du véhicule et du son provenant de la source de signaux audio (2, 5).

6. Système d'amélioration du son selon l'une quelconque des revendications précédentes, caractérisé de plus par un système d'annulation de bruit (30, 31, 32) comprenant au moins un microphone de détection d'erreur (31), un organe de commande d'annulation de bruit (30) et des moyens (32) pour fournir les signaux émis par le ou chaque microphone de détection d'erreur (31) à destination de l'organe de commande de suppression de bruit (30), cet organe de commande de suppression de bruit (30) étant apte à produire des signaux de suppression de bruit de façon adaptée en réponse au signal de sortie du ou de chaque microphone de détection d'erreur (31) pour réduire les bruits indésirés, le système comprenant un mélangeur (9) apte à mélanger les signaux de sortie et les signaux de suppression de bruit pour produire le son de marche simulée du véhicule.

7. Système d'amélioration du son selon la revendication 3, caractérisé par une mémoire, au moins un microphone de détection d'erreur (31) et des moyens (32), pour fournir des signaux émis par le ou chaque microphone de détection d'erreur (31) à destination du microprocesseur (25), le microprocesseur (25) étant opérant pour adapter les signaux stockés en réponse aux signaux provenant du ou de chaque microphone de détection d'erreur (31) de telle sorte que le bruit de marche simulée du véhicule produit par le synthétiseur (24) atteint un son de marche prédéterminé du véhicule défini dans la mémoire ou dans le microprocesseur (25).

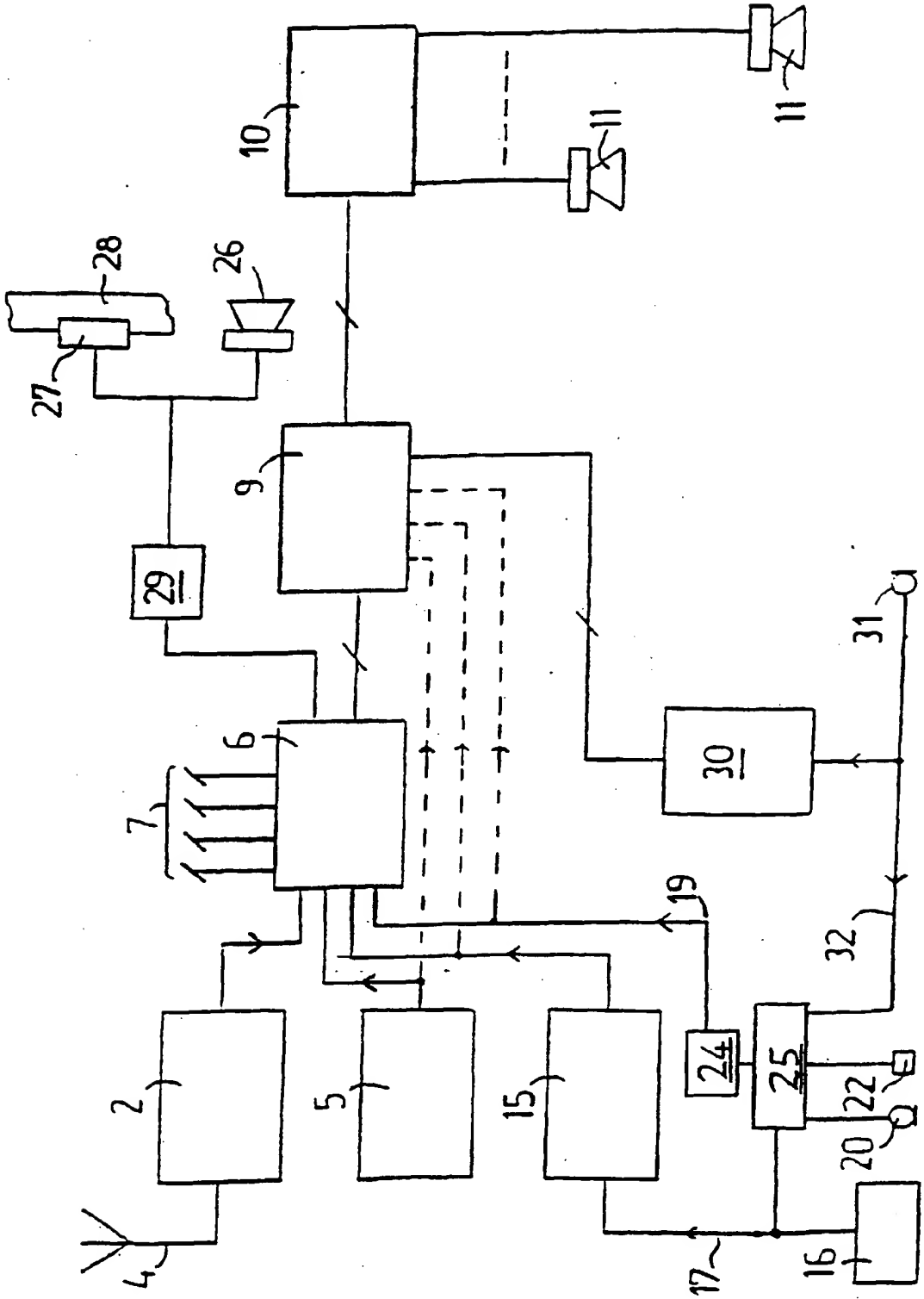

FIG.1